Fig.1

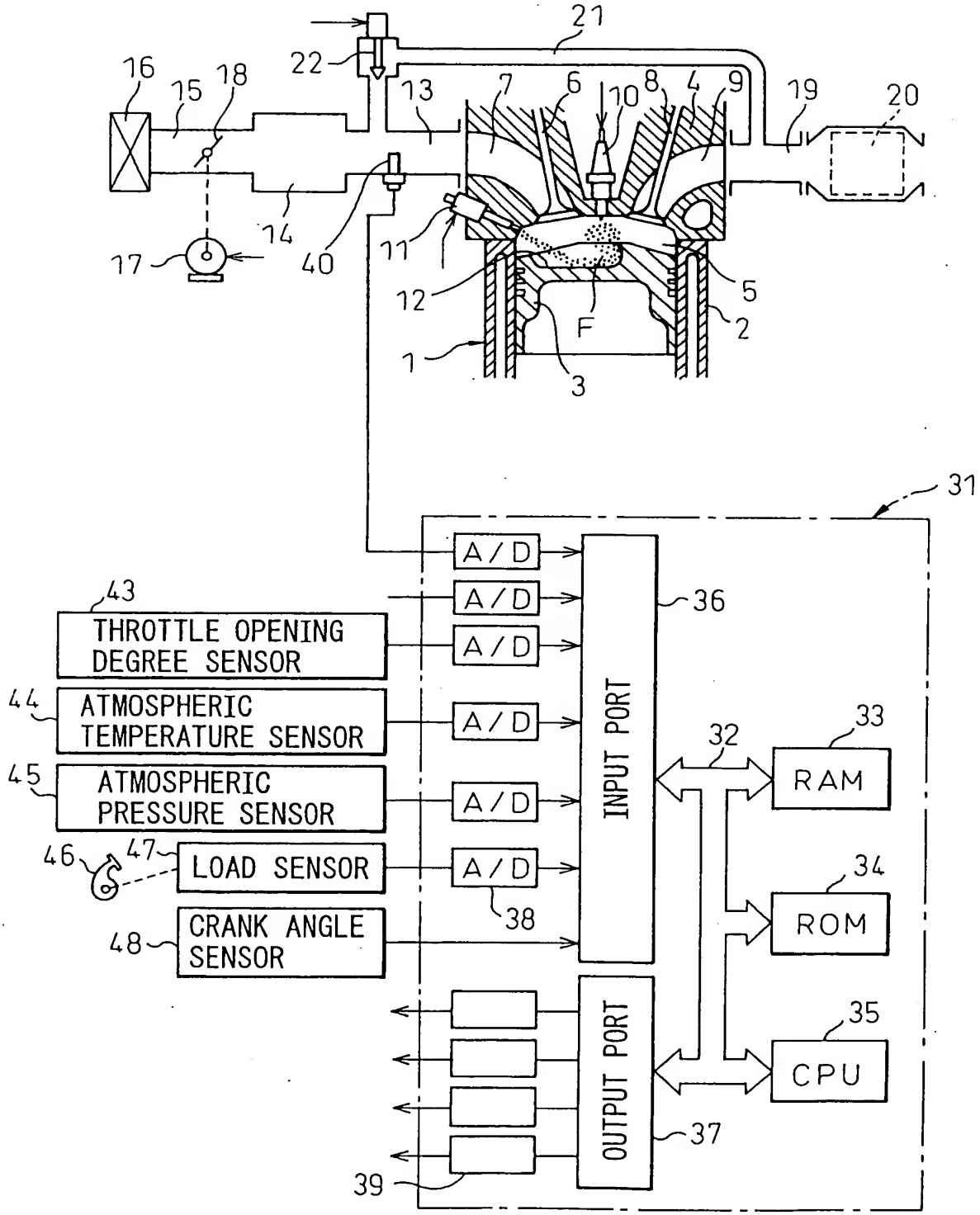

21
22
16
15
18
13
7
6
10
8
4
9
19
20
14
17
40
11
12
5
F
2
1
3
31
A/D
A/D
A/D
A/D
A/D
A/D
43
THROTTLE OPENING DEGREE SENSOR
44
ATMOSPHERIC TEMPERATURE SENSOR
45
ATMOSPHERIC PRESSURE SENSOR
46
47
LOAD SENSOR
48
CRANK ANGLE SENSOR
38
36
INPUT PORT
32
33
RAM
34
ROM
35
CPU
OUTPUT PORT
37
39

Fig.2

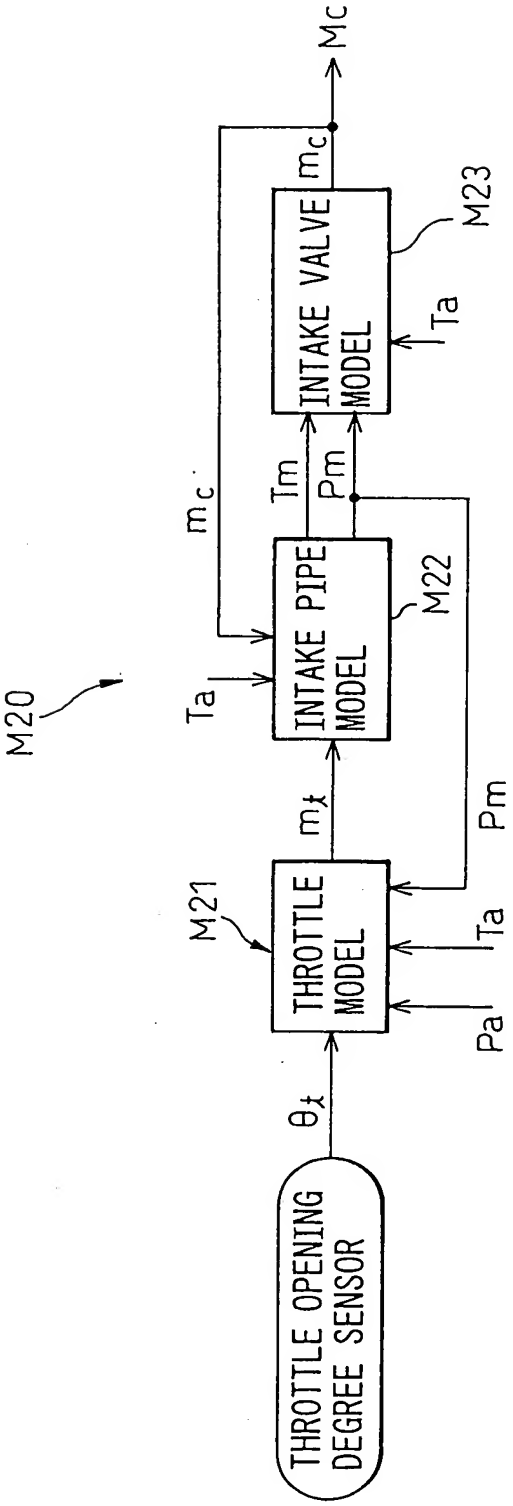

M20
THROTTLE OPENING DEGREE SENSOR
θt
M21
THROTTLE MODEL
mt
Pa
Ta
Pm
M22
INTAKE PIPE MODEL
Ta
mc
Tm
Pm
M23
INTAKE VALVE MODEL
Ta
mc
Mc

Fig.3

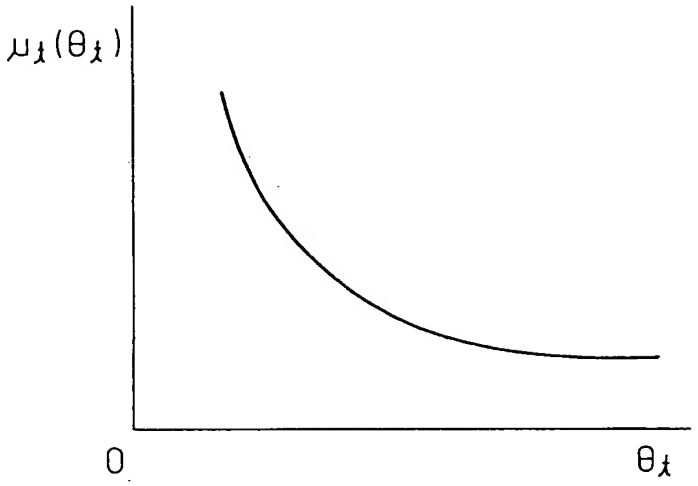


Fig.4

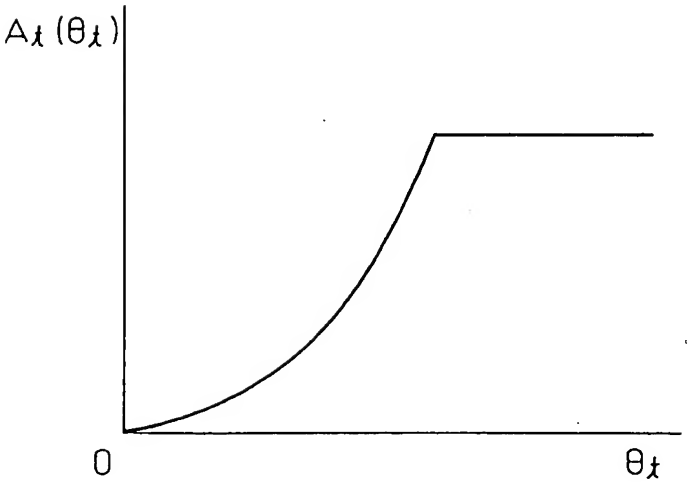


Fig.5

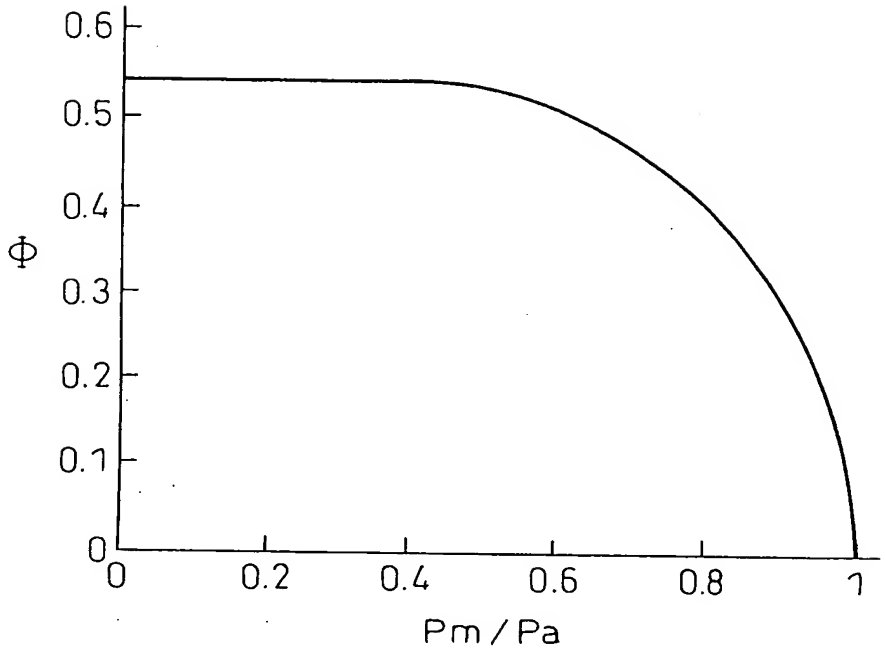
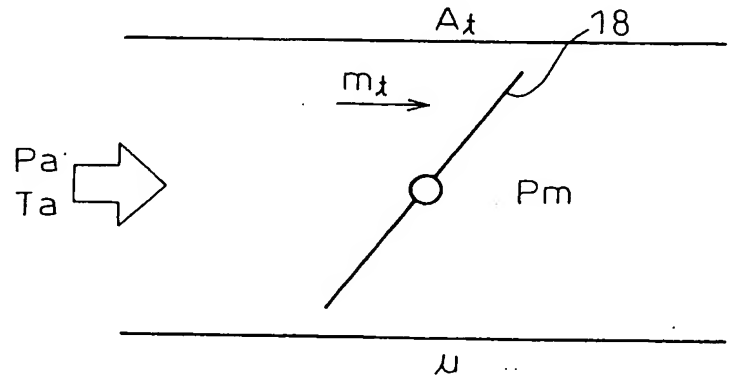
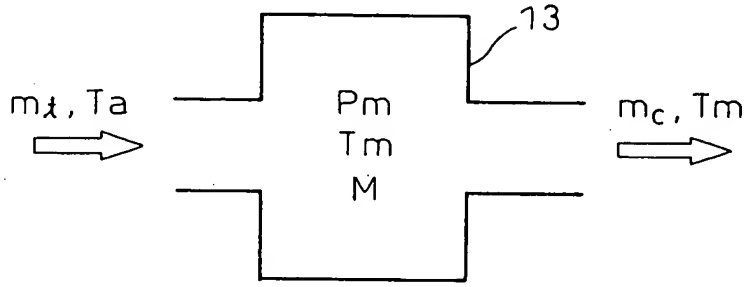


Fig.6



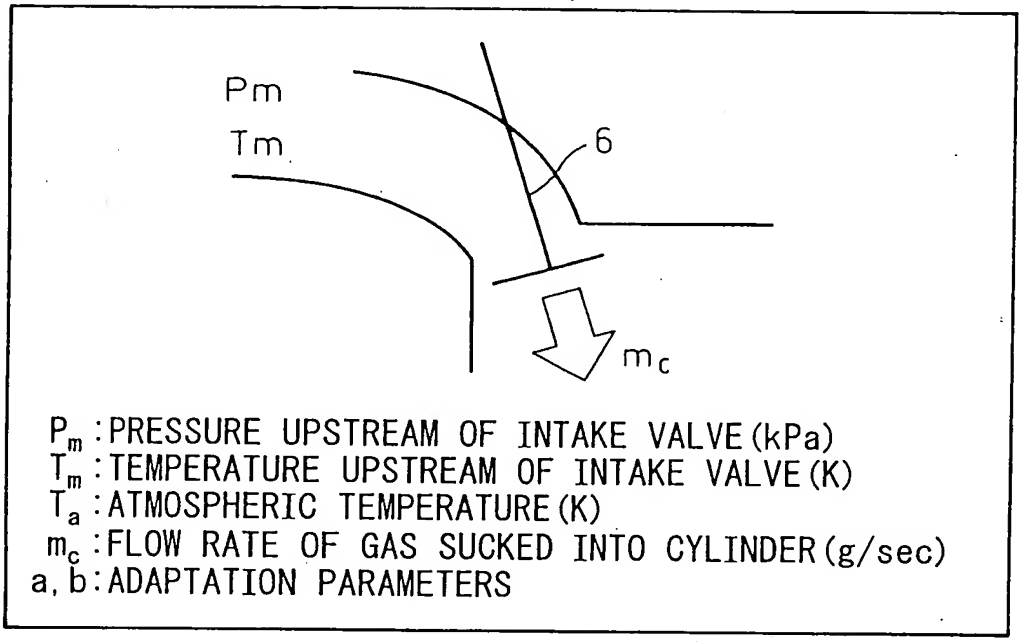
P_m : INTAKE PIPE PRESSURE (kPa)
P_a : ATMOSPHERIC PRESSURE (kPa)
T_a : ATMOSPHERIC TEMPERATURE (K)
A_t : CROSS SECTIONAL AREA OF OPENING OF THROTTLE VALVE (m^2)
m_t : FLOW RATE OF AIR PASSING THROUGH THROTTLE VALVE (g/sec)
μ : FLOW RATE COEFFICIENT

Fig.7



m_t : FLOW RATE OF GAS FLOWING INTO INTAKE PIPE (g/sec)
m_c : FLOW RATE OF GAS FLOWING OUT FROM INTAKE PIPE (g/sec)
P_m : INTAKE PIPE PRESSURE (kPa)
T_a : TEMPERATURE OF GAS FLOWING INTO INTAKE PIPE (K)
T_m : TEMPERATURE IN INTAKE PIPE (K)
M : TOTAL AMOUNT OF GAS IN INTAKE PIPE
R : GAS CONSTANT
V_m : VOLUME OF INTAKE PIPE (m^3)
C_p : SPECIFIC HEAT AT CONSTANT PRESSURE
C_v : SPECIFIC HEAT AT CONSTANT VOLUME
K : SPECIFIC HEAT RATIO

Fig.8



P_m : PRESSURE UPSTREAM OF INTAKE VALVE (kPa)
T_m : TEMPERATURE UPSTREAM OF INTAKE VALVE (K)
T_a : ATMOSPHERIC TEMPERATURE (K)
m_c : FLOW RATE OF GAS SUCKED INTO CYLINDER (g/sec)
a, b : ADAPTATION PARAMETERS

Fig.9

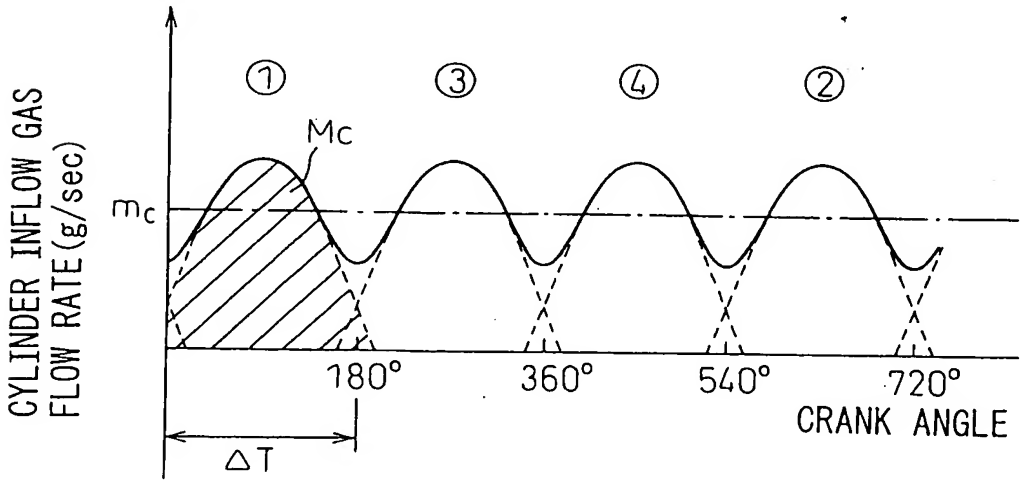


Fig.10

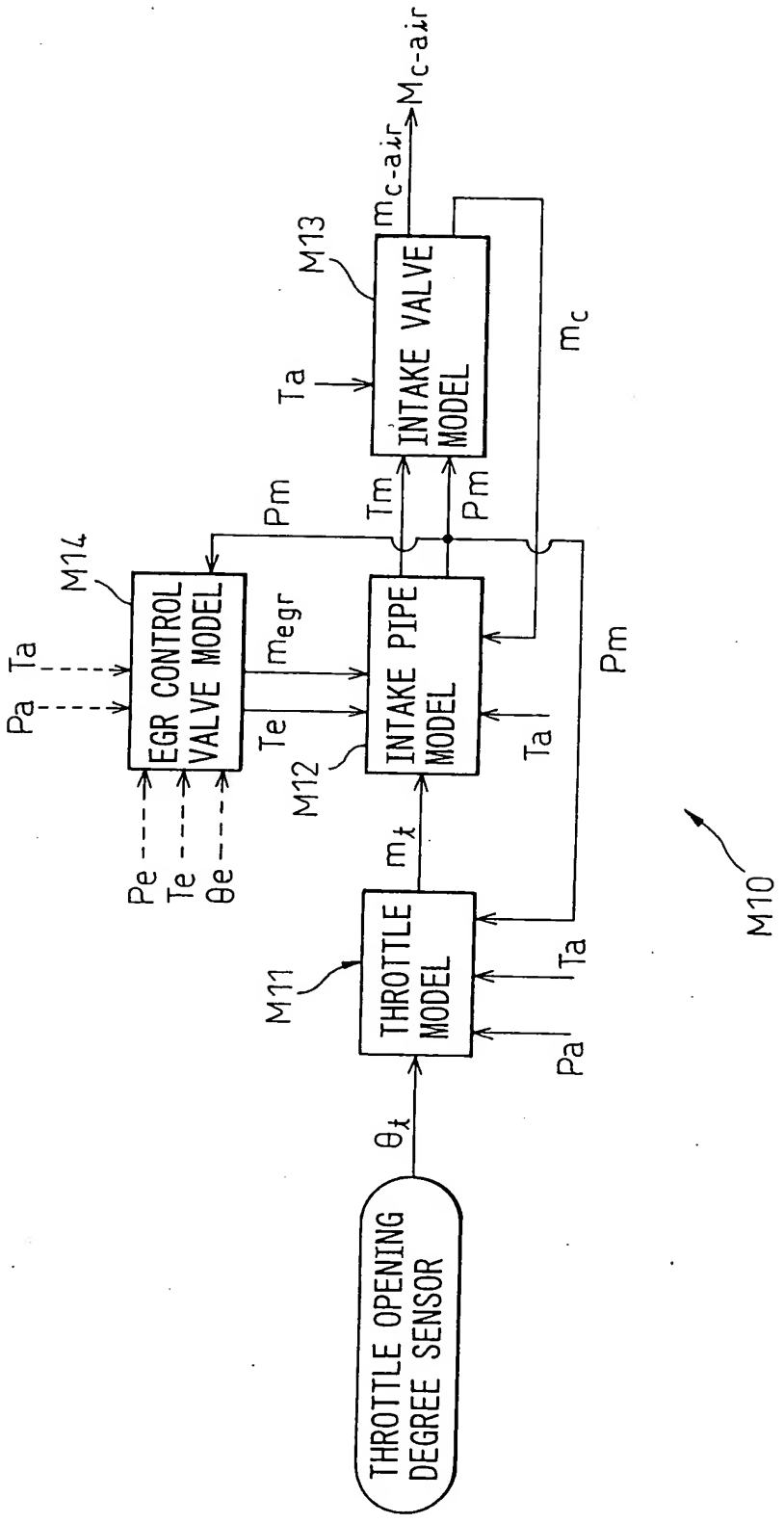
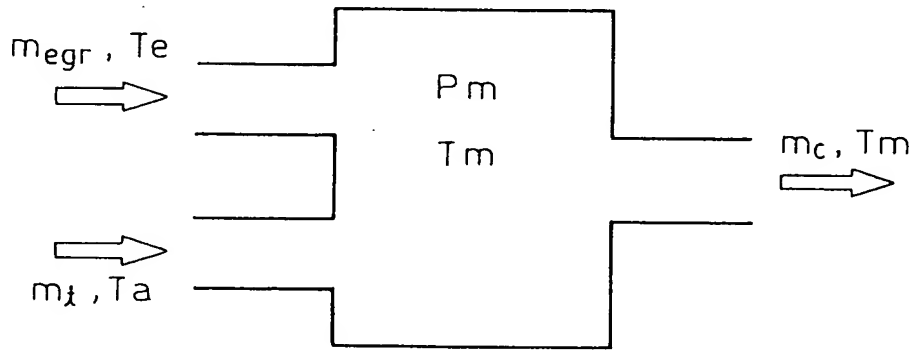
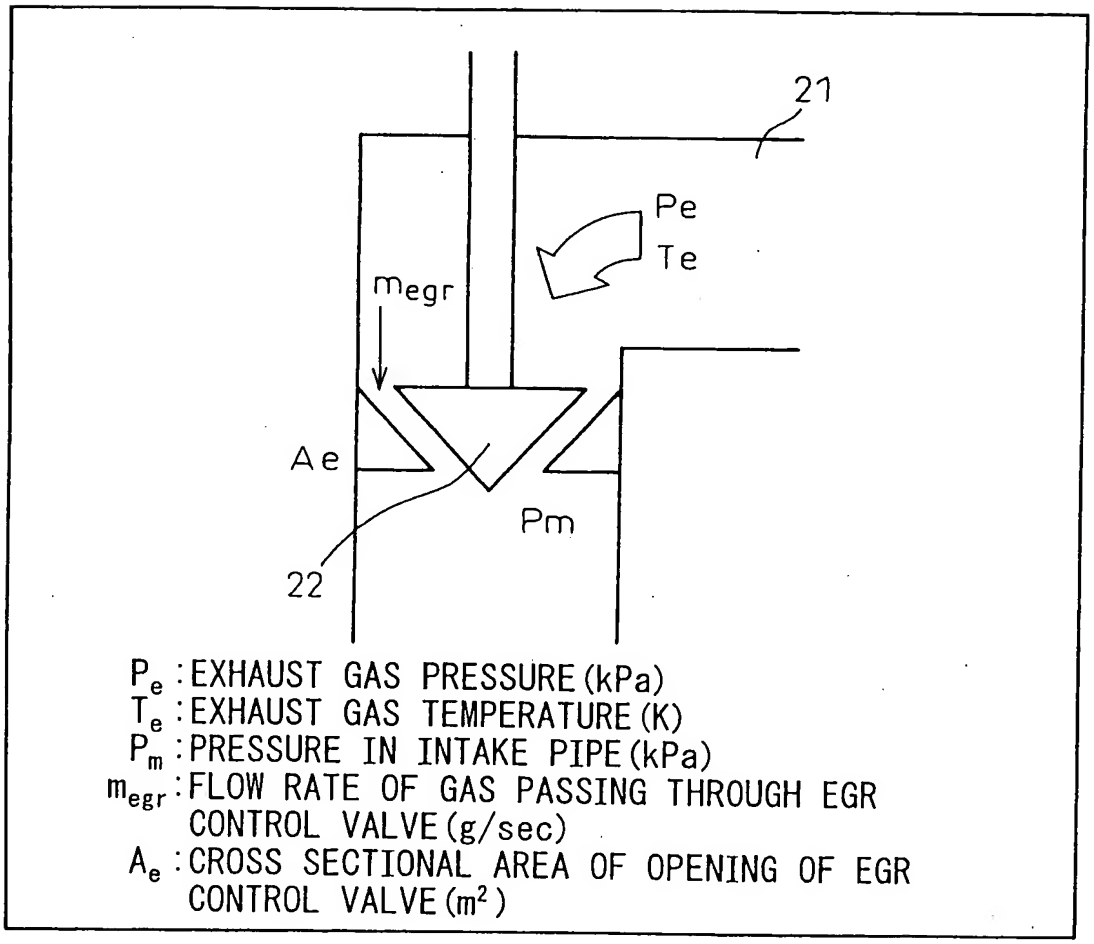

THROTTLE OPENING DEGREE SENSOR
θt
THROTTLE MODEL
M11
mt
Pa
Ta
INTAKE PIPE MODEL
M12
Te
Pm
Tm
EGR CONTROL VALVE MODEL
M14
Pe
θe
megr
Ta
Pa
INTAKE VALVE MODEL
M13
mc-air
Mc-air
mc
M10

Fig.11



m_{egr} :FLOW RATE OF GAS PASSING THROUGH EGR CONTROL VALVE (g/sec)
m_t :FLOW RATE OF AIR PASSING THROUGH THROTTLE VALVE (g/sec)
m_c :FLOW RATE OF GAS SUCKED INTO CYLINDER (g/sec)
T_e :EXHAUST GAS TEMPERATURE (K)
T_a :ATMOSPHERIC TEMPERATURE OR INTAKE AIR TEMPERATURE (K)
T_m :TEMPERATURE IN INTAKE PIPE (K)
P_m :PRESSURE IN INTAKE PIPE (kPa)

Fig.12



P_e : EXHAUST GAS PRESSURE (kPa)
T_e : EXHAUST GAS TEMPERATURE (K)
P_m : PRESSURE IN INTAKE PIPE (kPa)
m_{egr} : FLOW RATE OF GAS PASSING THROUGH EGR CONTROL VALVE (g/sec)
A_e : CROSS SECTIONAL AREA OF OPENING OF EGR CONTROL VALVE (m^2)

Fig.13

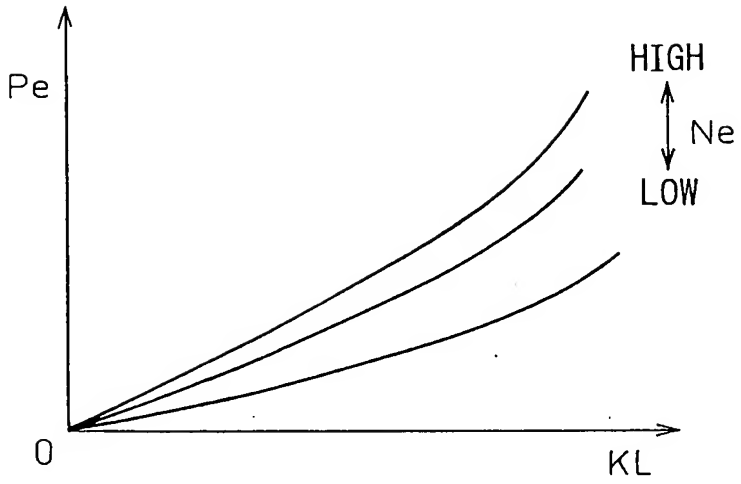


Fig.14

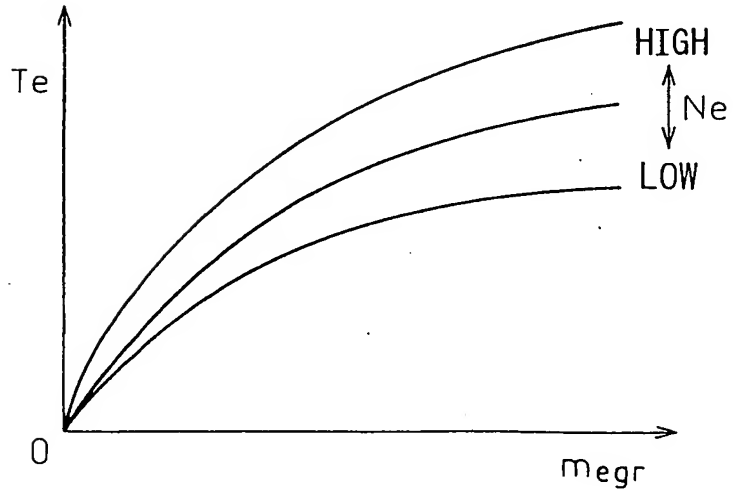


Fig.15

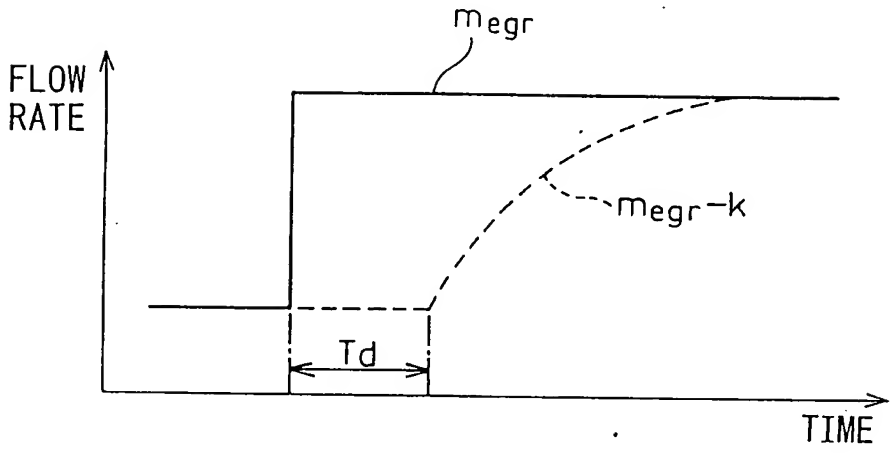


Fig.16A

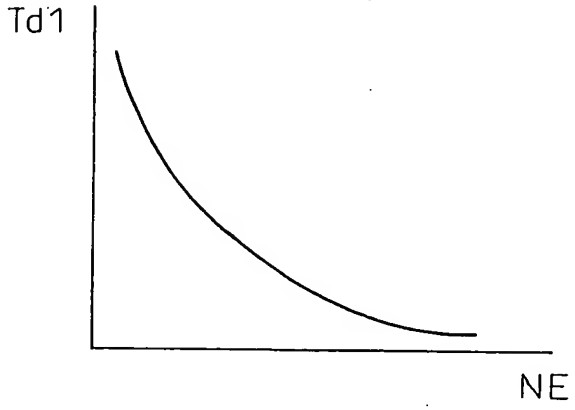


Fig.16B

Fig.17A

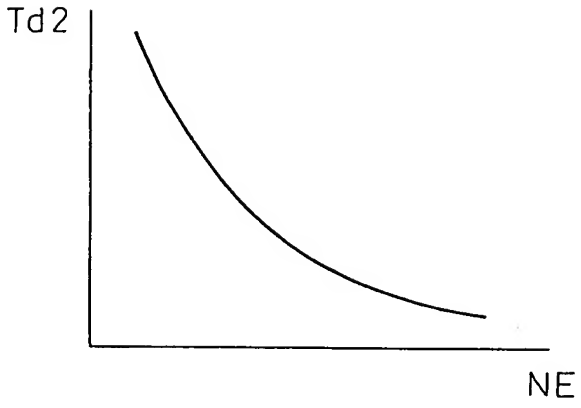


Fig.17B

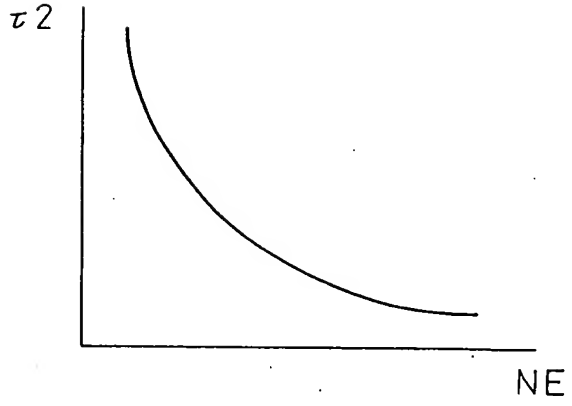


Fig.18

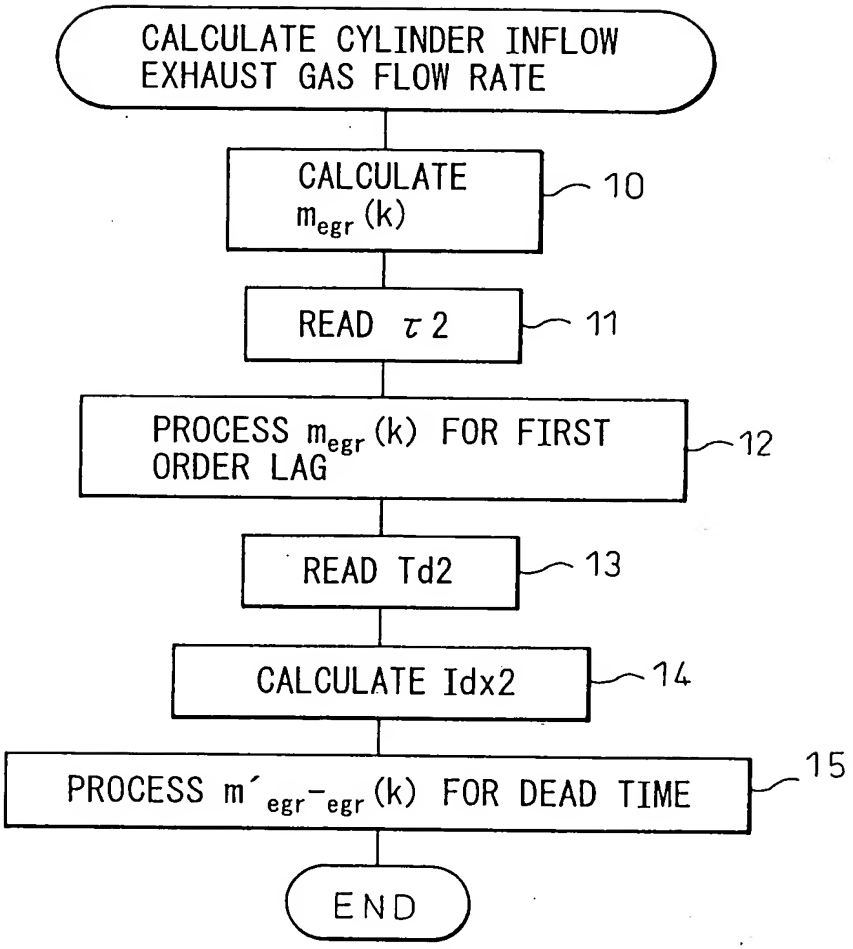

CALCULATE CYLINDER INFLOW EXHAUST GAS FLOW RATE
CALCULATE $m_{egr}(k)$
10
READ $\tau 2$
11
PROCESS $m_{egr}(k)$ FOR FIRST ORDER LAG
12
READ Td2
13
CALCULATE Idx2
14
PROCESS $m'_{egr-egr}(k)$ FOR DEAD TIME
15
END

Fig.19A

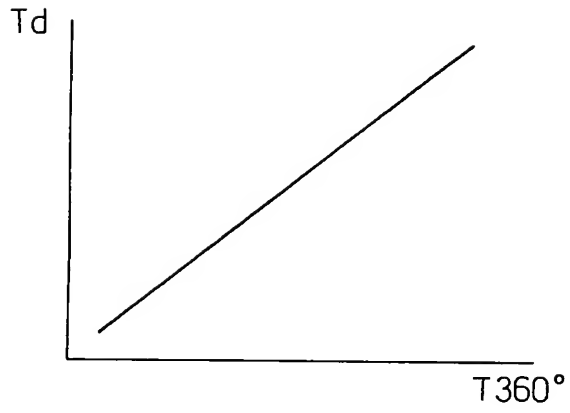


Fig.19B

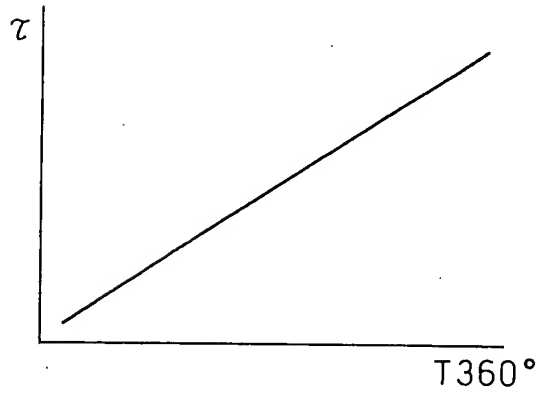


Fig. 20A

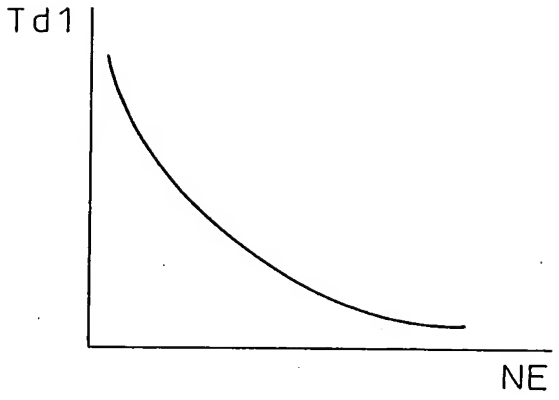


Fig. 20B

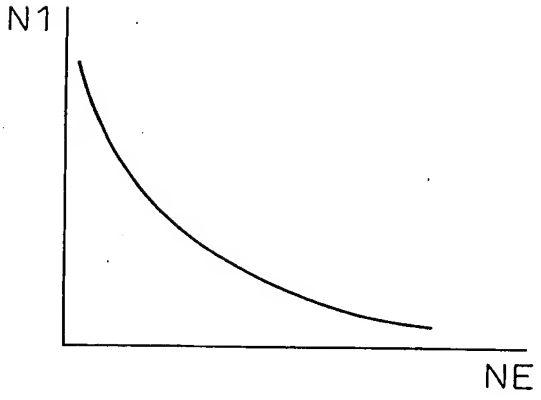


Fig. 21A

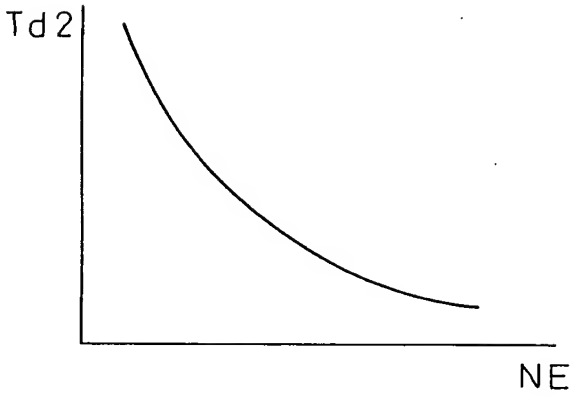


Fig. 21B

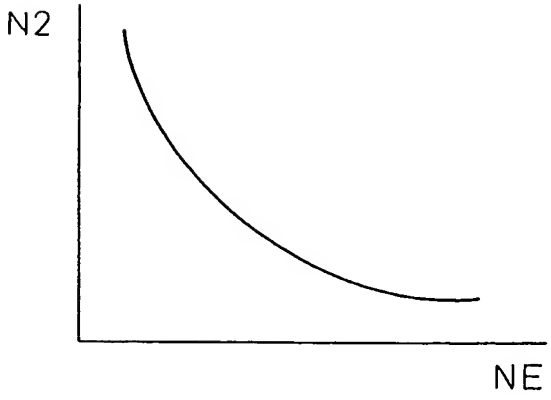


Fig. 22

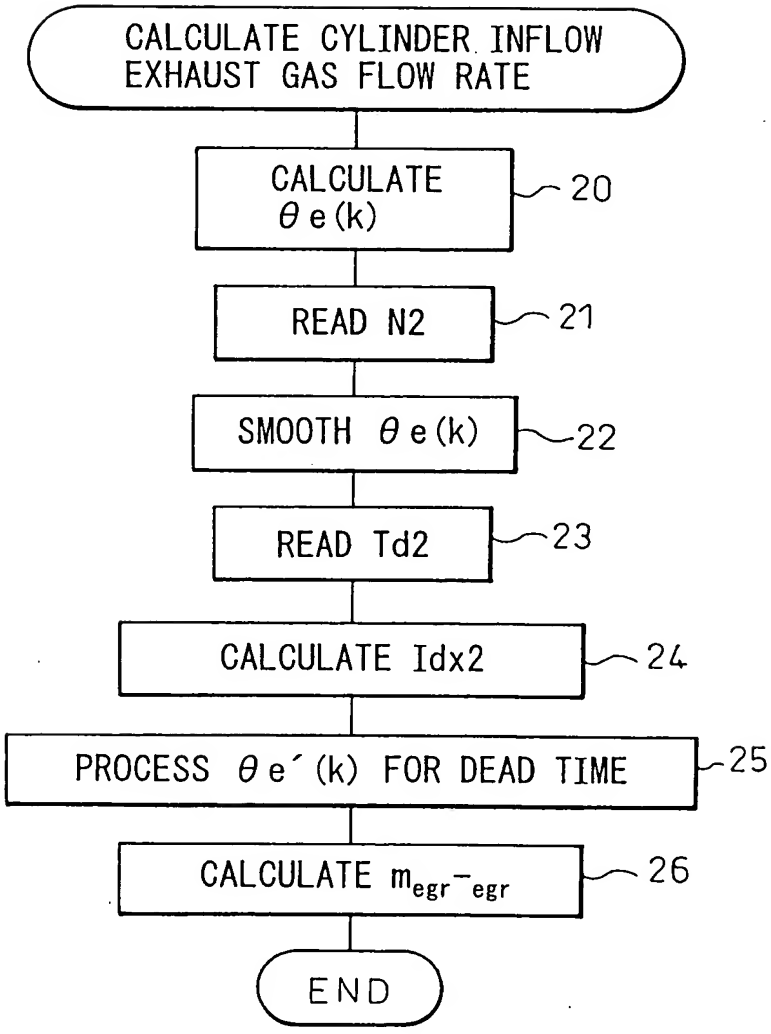

CALCULATE CYLINDER INFLOW EXHAUST GAS FLOW RATE
CALCULATE θe(k)
20
READ N2
21
SMOOTH θe(k)
22
READ Td2
23
CALCULATE Idx2
24
PROCESS θe´(k) FOR DEAD TIME
25
CALCULATE m_{egr}-$_{egr}$
26
END

Fig. 23

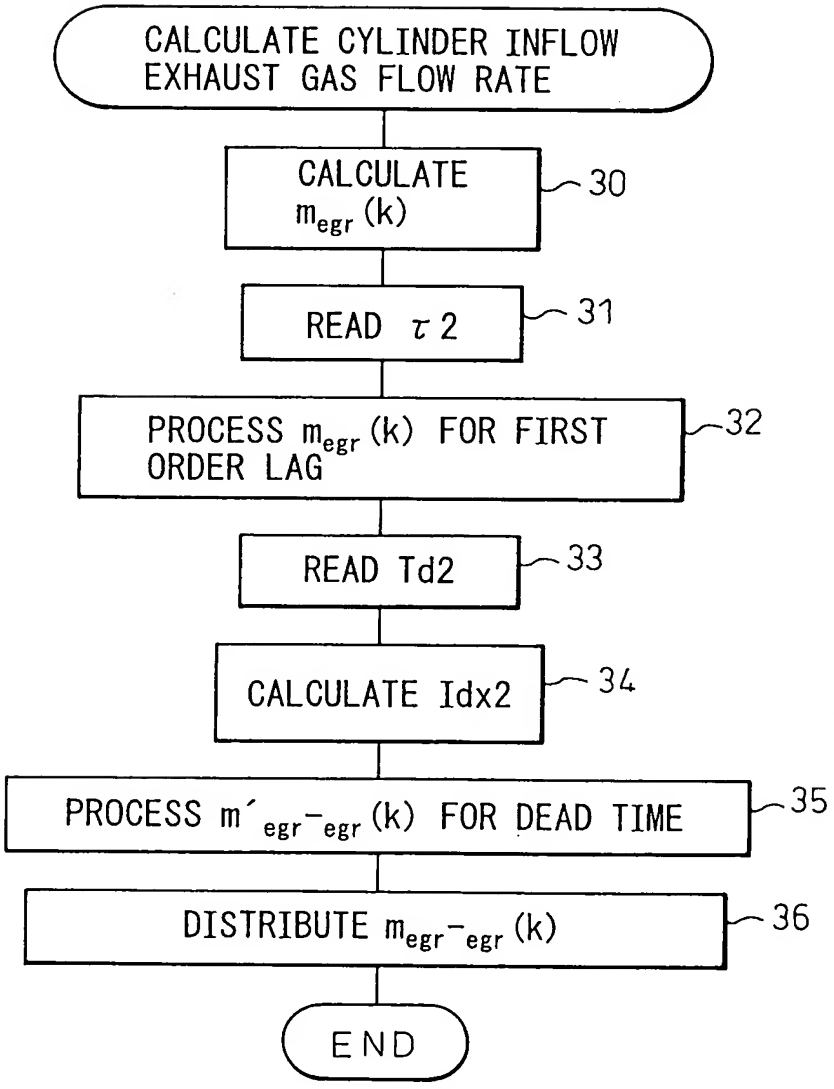

CALCULATE CYLINDER INFLOW EXHAUST GAS FLOW RATE
CALCULATE $m_{egr}(k)$
30
READ $\tau 2$
31
PROCESS $m_{egr}(k)$ FOR FIRST ORDER LAG
32
READ Td2
33
CALCULATE Idx2
34
PROCESS $m'_{egr-egr}(k)$ FOR DEAD TIME
35
DISTRIBUTE $m_{egr-egr}(k)$
36
END

Fig. 24

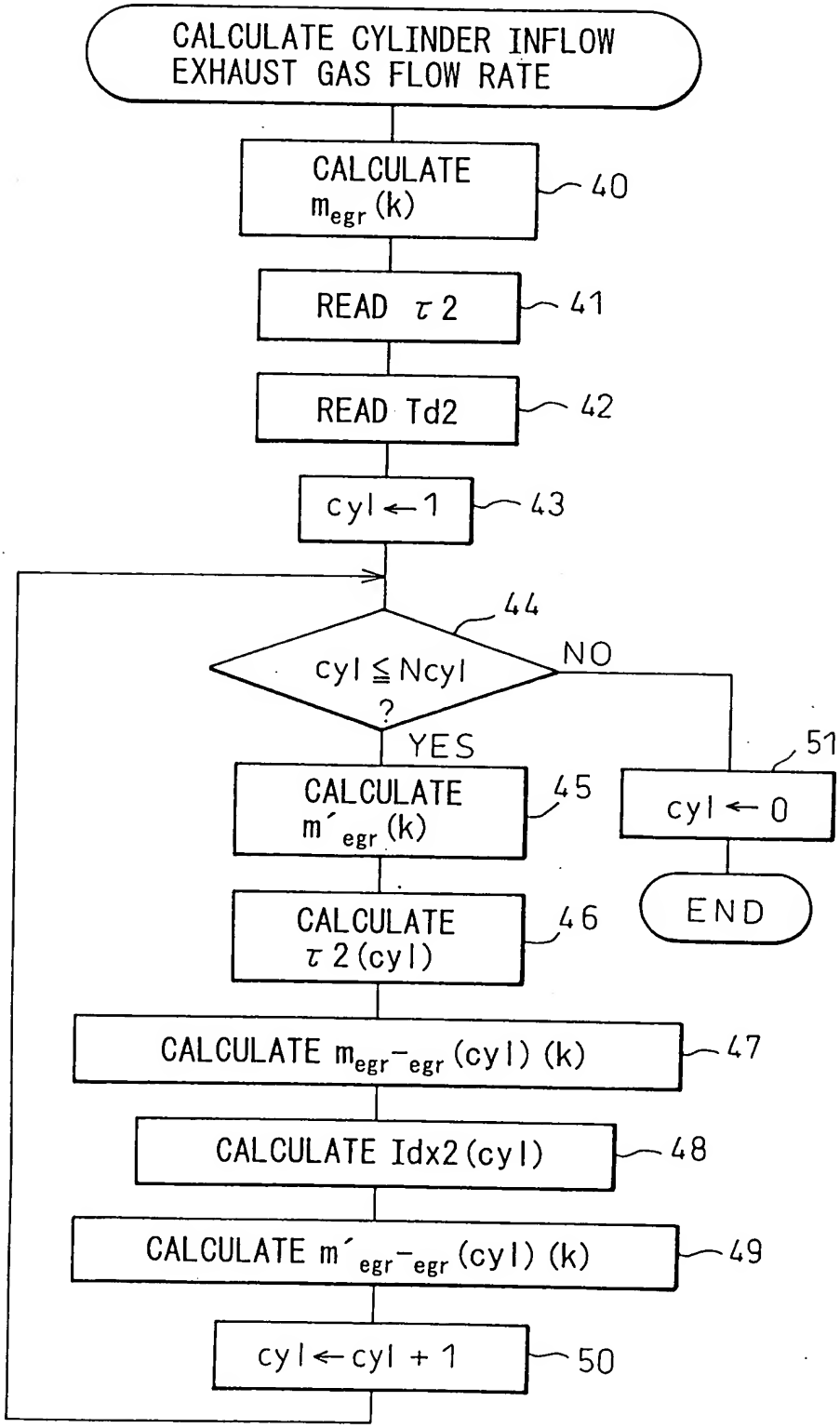

CALCULATE CYLINDER INFLOW EXHAUST GAS FLOW RATE
CALCULATE $m_{egr}(k)$
40
READ $\tau 2$
41
READ Td2
42
cyl ← 1
43
44
cyl ≦ Ncyl ?
NO
YES
51
CALCULATE $m'_{egr}(k)$
45
cyl ← 0
END
CALCULATE $\tau 2(cyl)$
46
CALCULATE $m_{egr-egr}(cyl)(k)$
47
CALCULATE Idx2(cyl)
48
CALCULATE $m'_{egr-egr}(cyl)(k)$
49
cyl ← cyl + 1
50

Fig. 25A

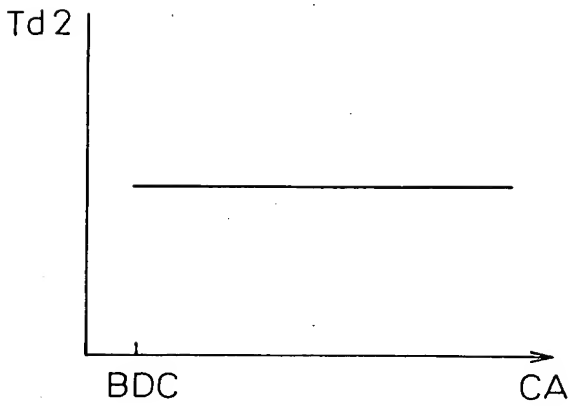


Fig. 25B

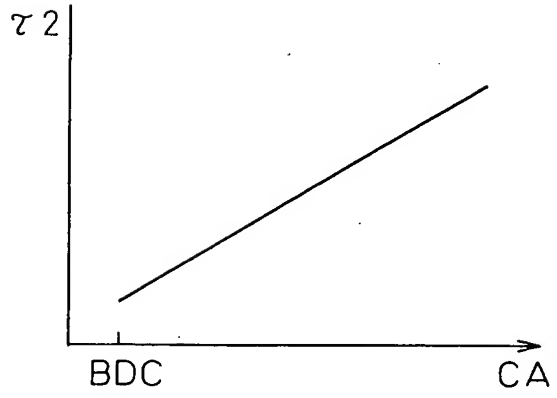


Fig. 26A

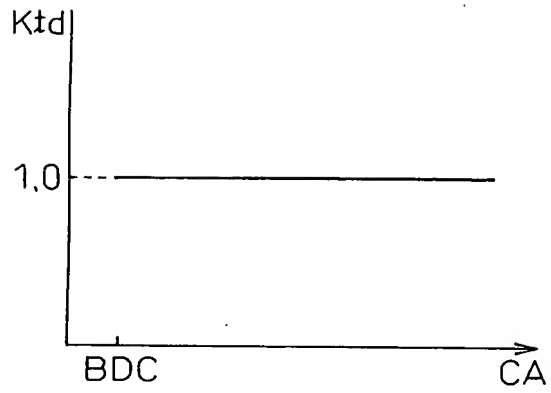


Fig. 26B

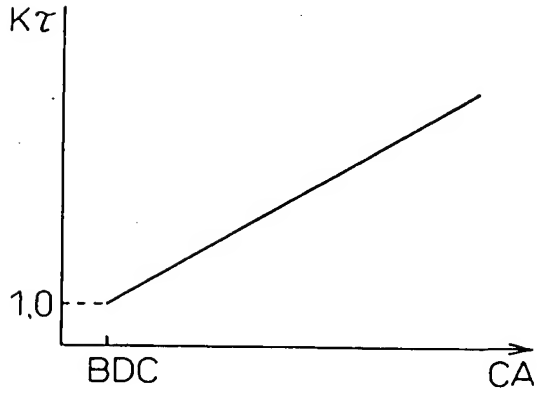


Fig.27A

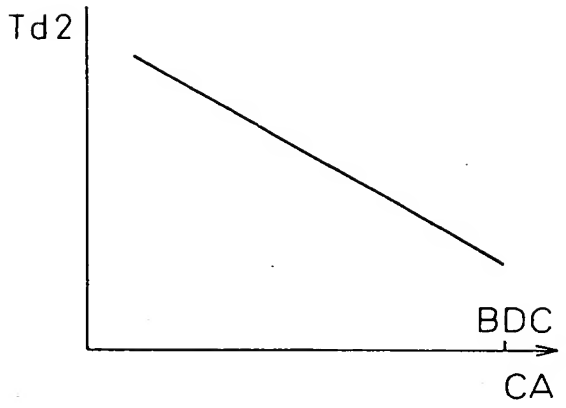


Fig.27B

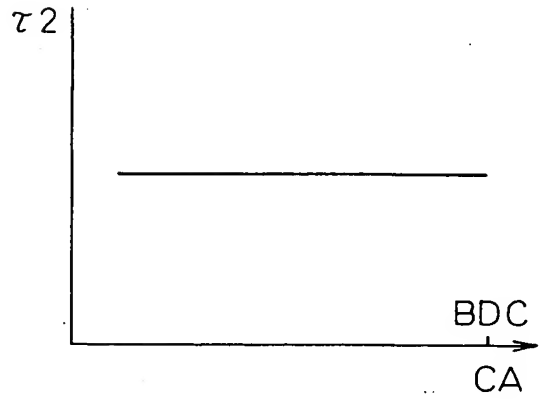


Fig. 28A

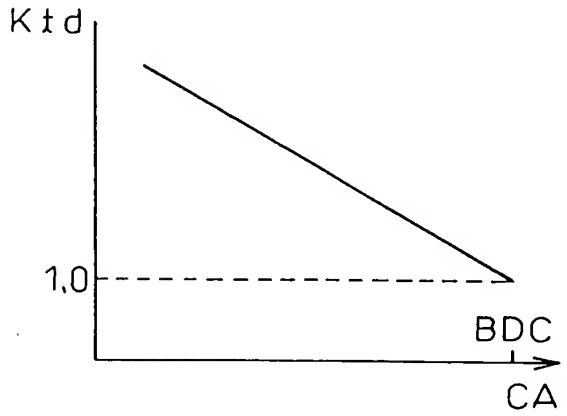


Fig. 28B

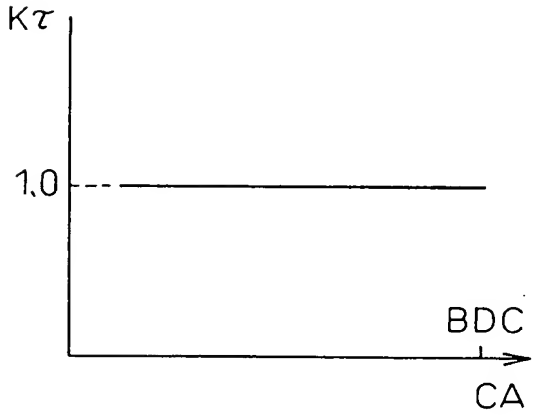


Fig.29A

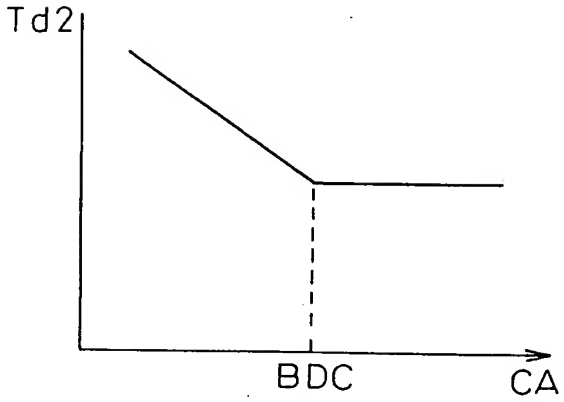


Fig.29B

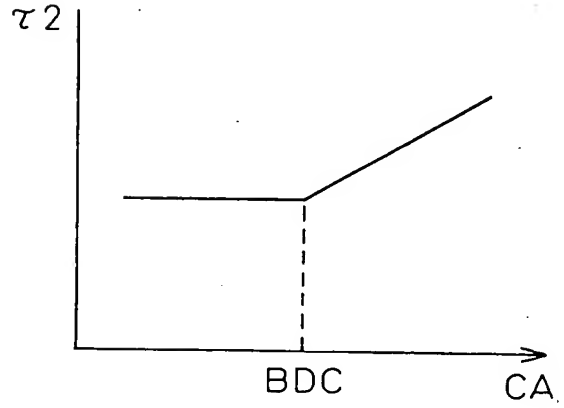


Fig.30A

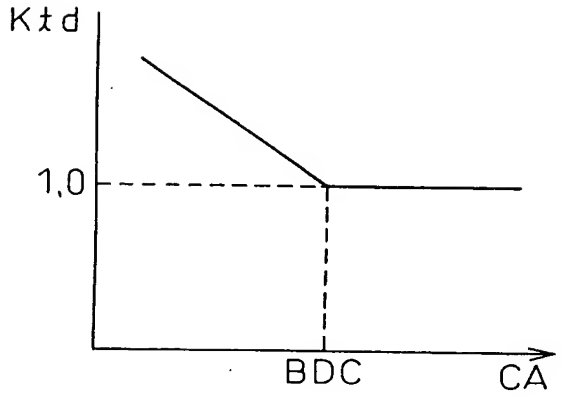


Fig.30B

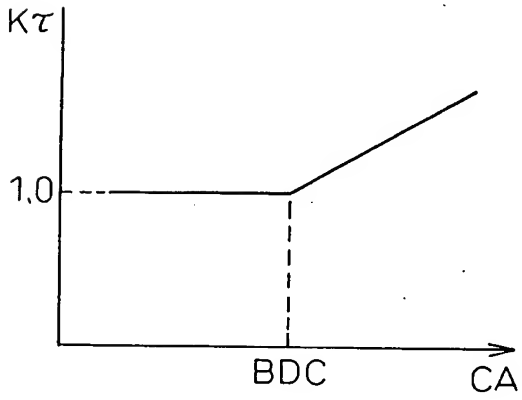


Fig.31

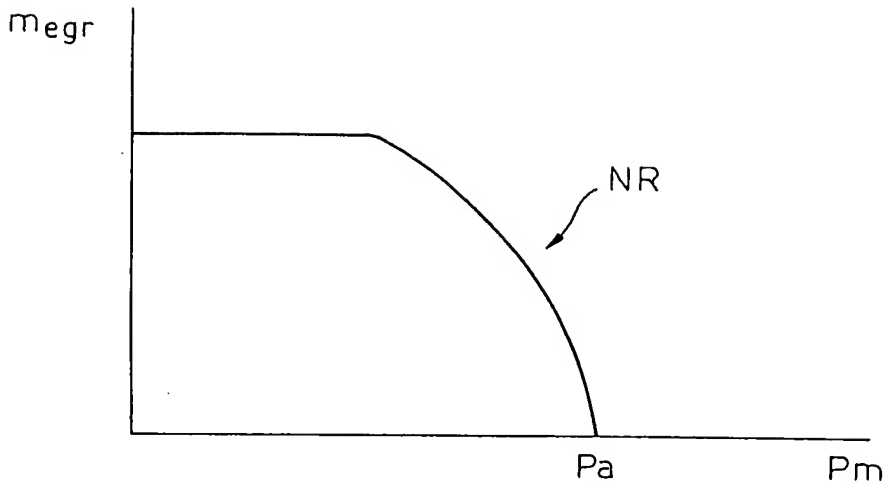


Fig.32

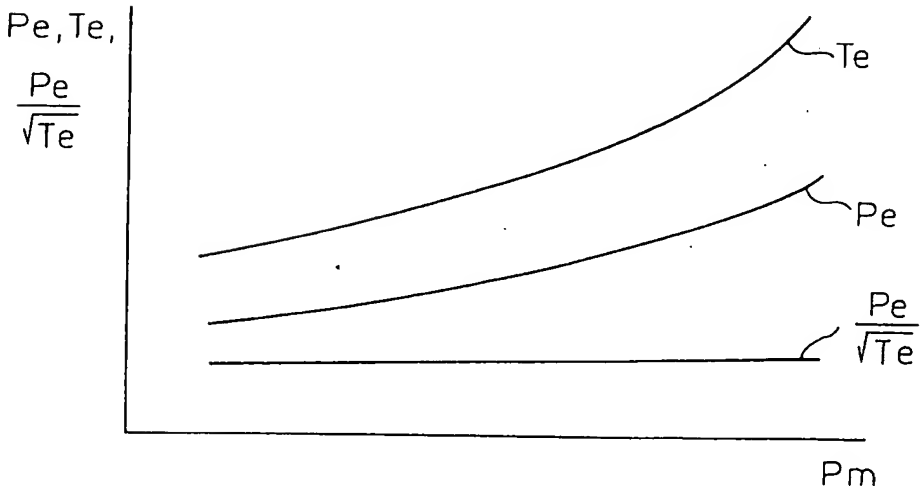


Fig.33A

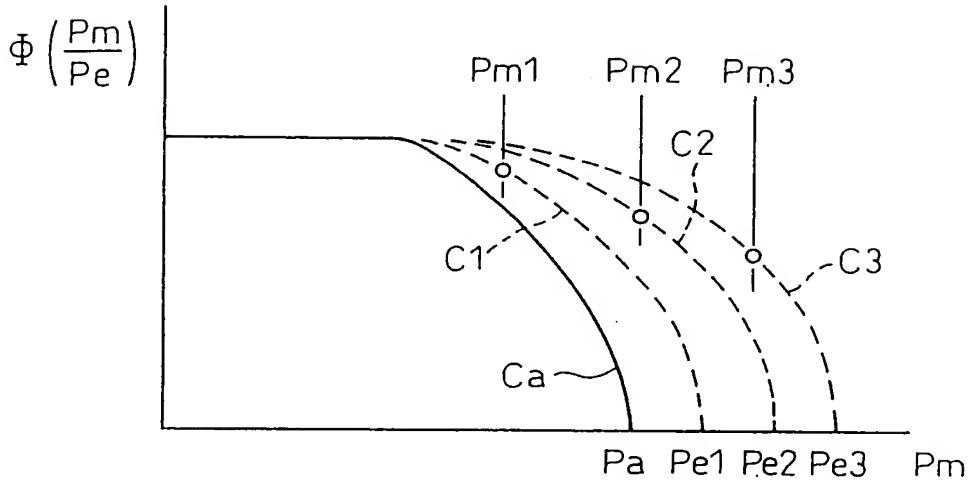


Fig.33B

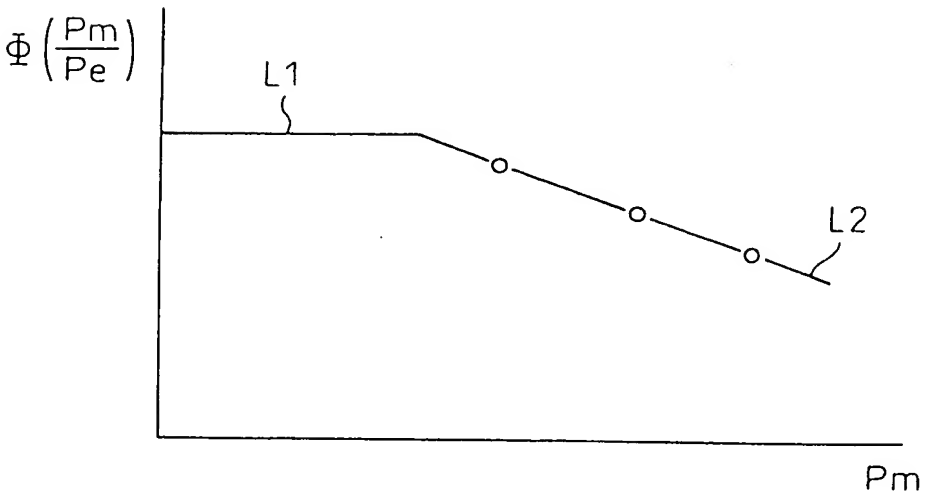


Fig.34

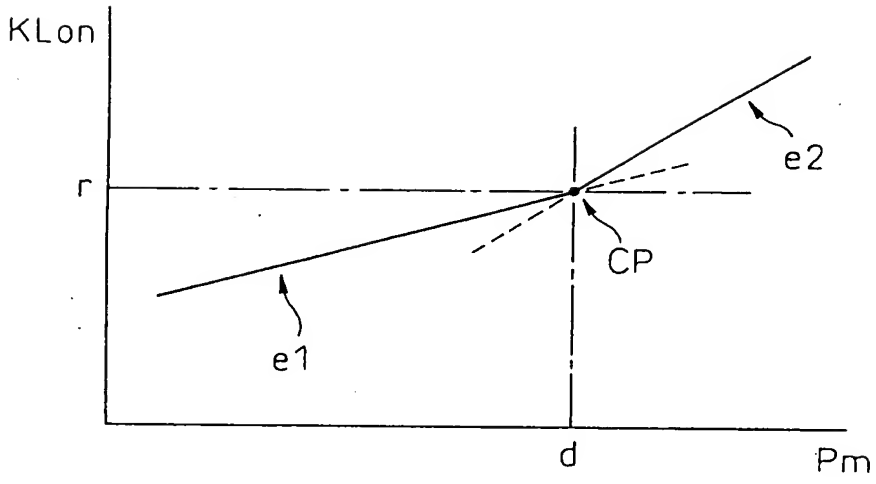


Fig.35A

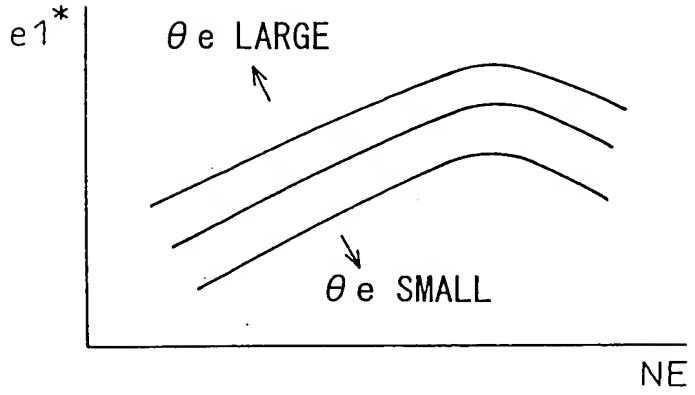


Fig.35B

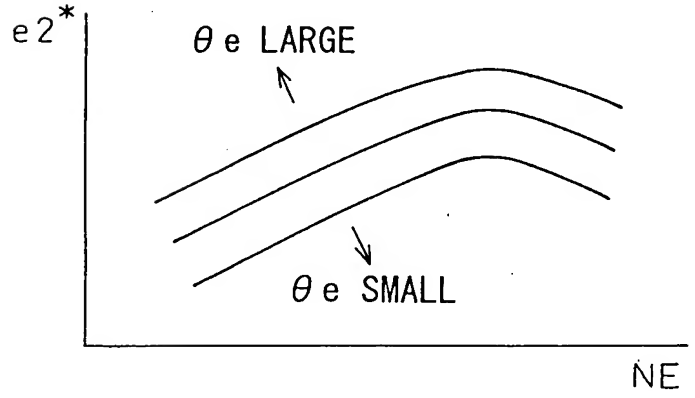


Fig.35C

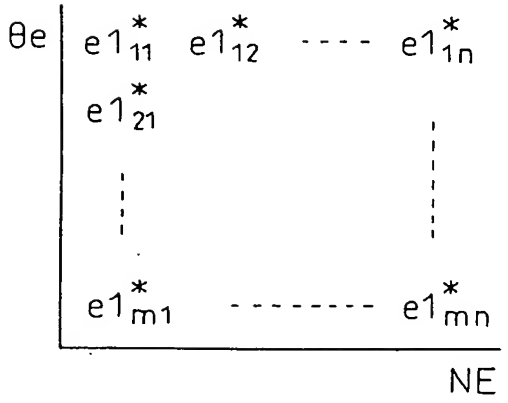


Fig.35D

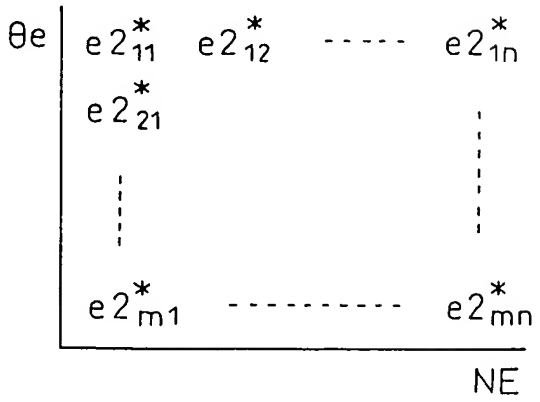


Fig.36

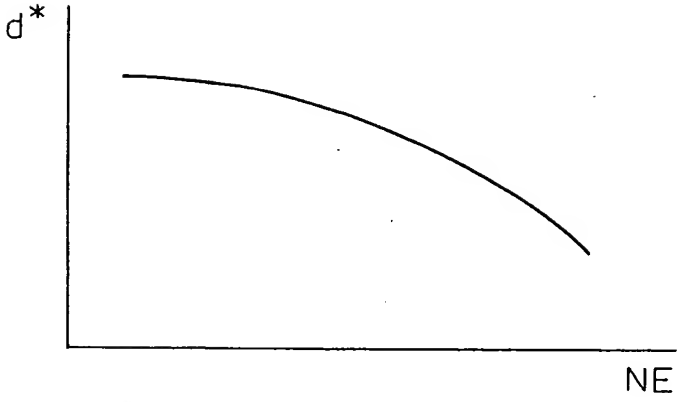


Fig.37A

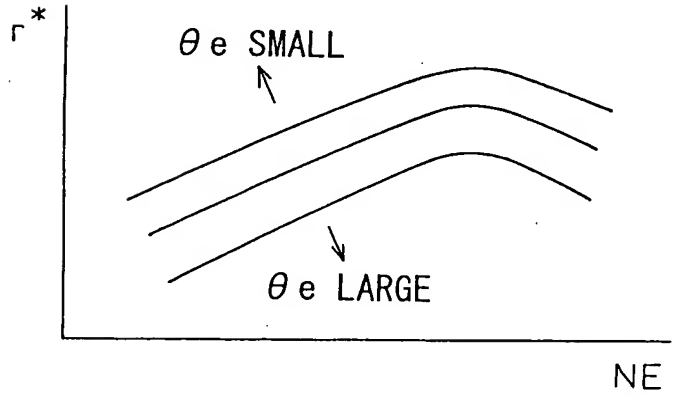


Fig.37B

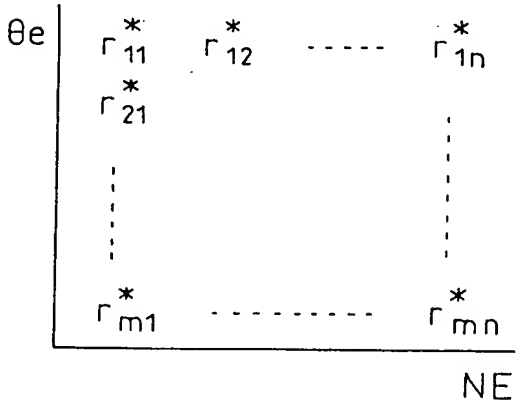


Fig.38

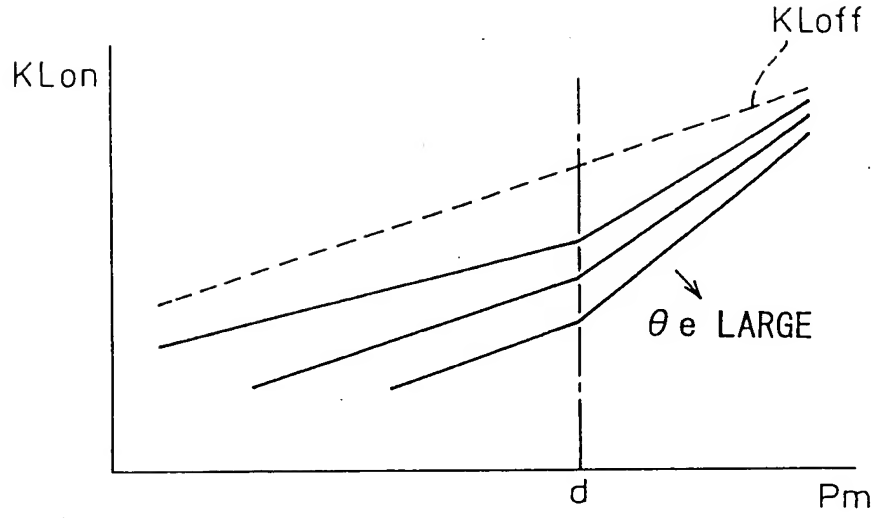


Fig.39

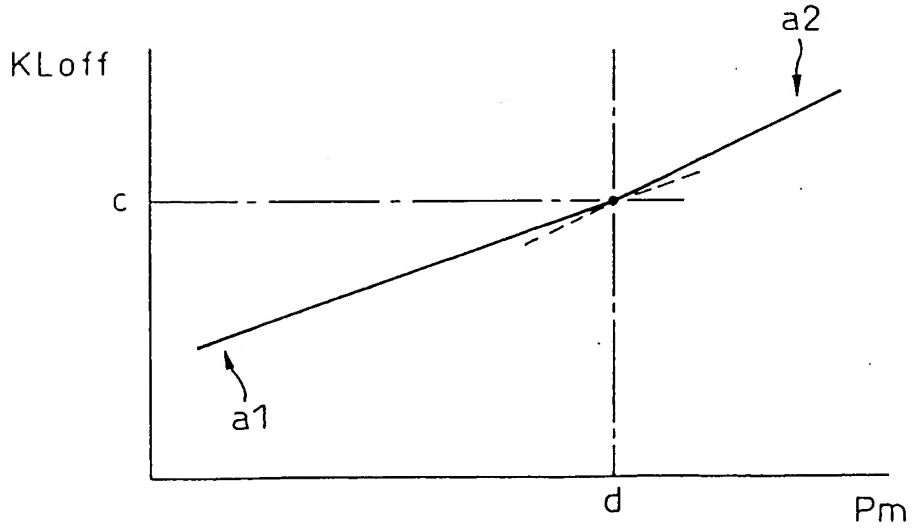


Fig. 40A

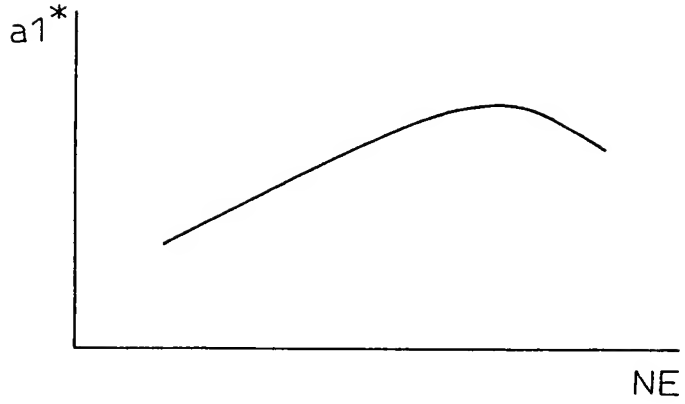


Fig. 40B

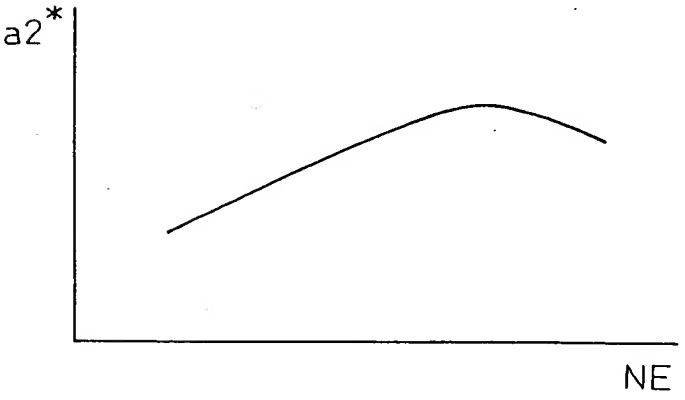


Fig. 41

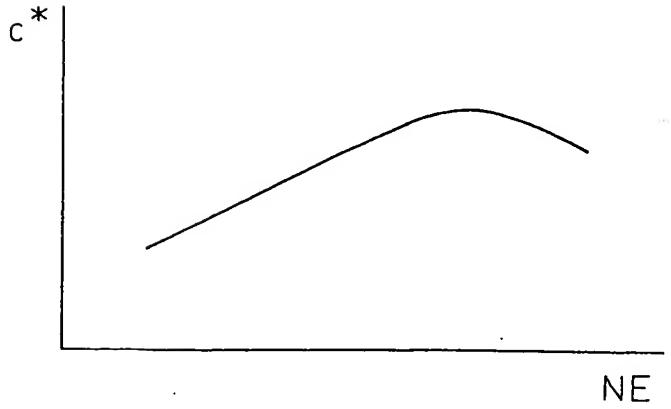


Fig. 42

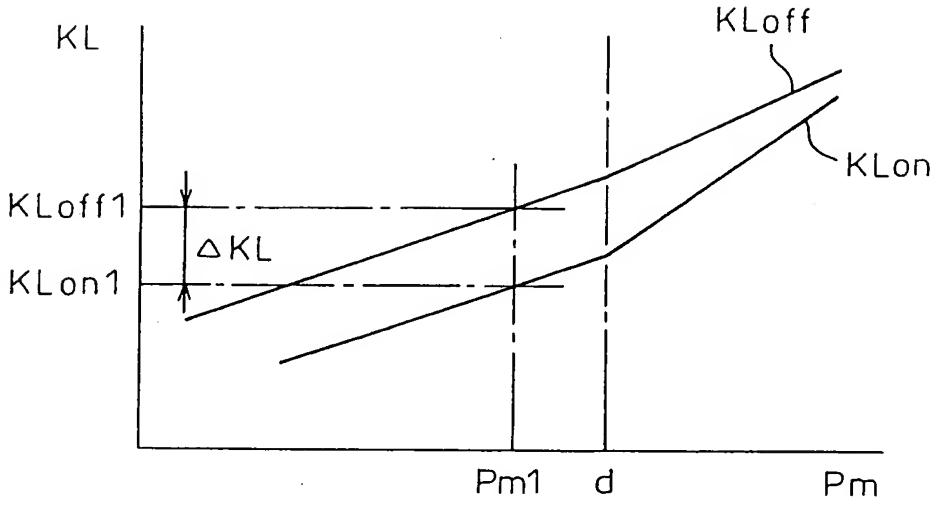


Fig.43

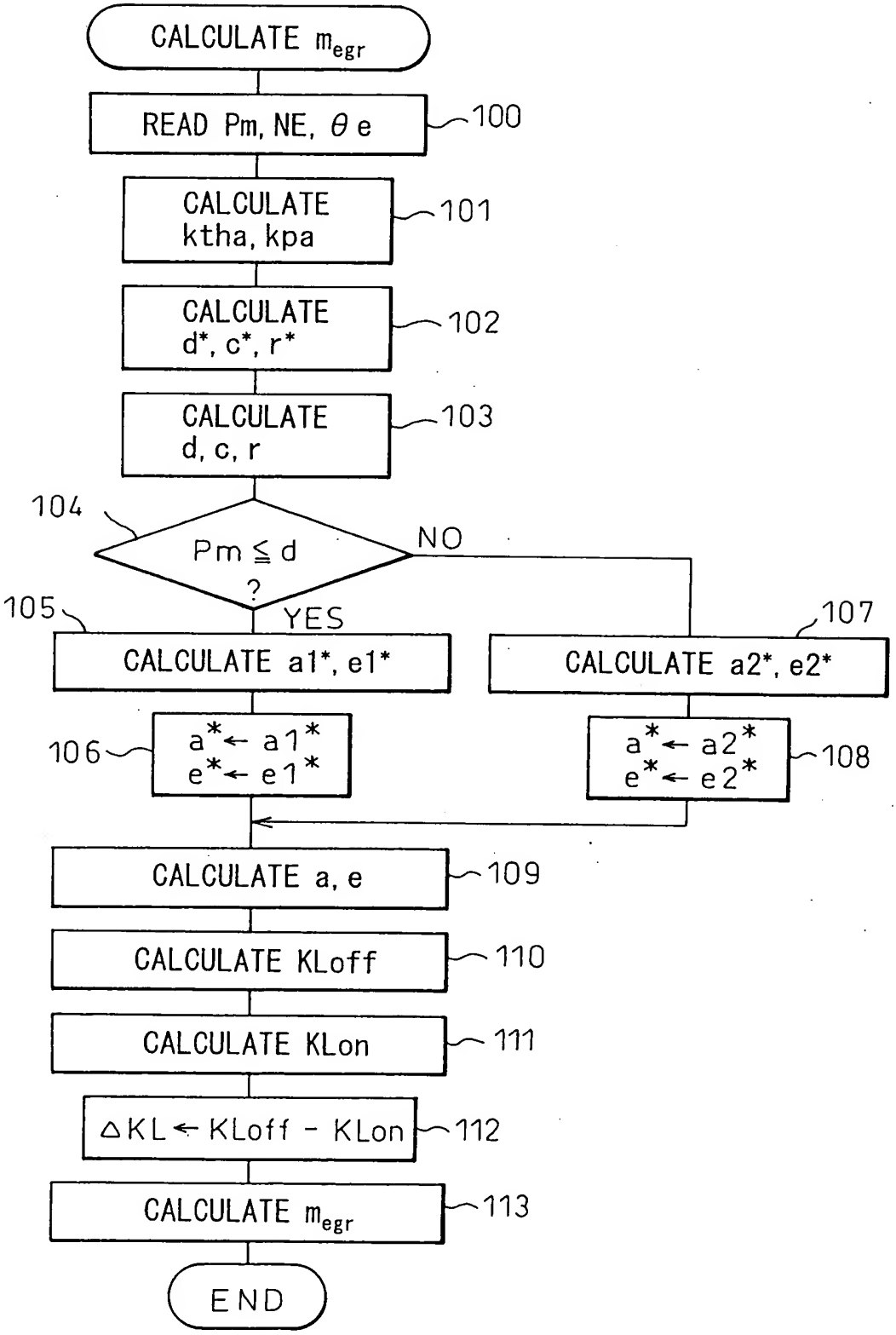

CALCULATE m_{egr}
READ Pm, NE, θe
100
CALCULATE ktha, kpa
101
CALCULATE d*, c*, r*
102
CALCULATE d, c, r
103
104
Pm ≦ d ?
NO
YES
105
CALCULATE a1*, e1*
107
CALCULATE a2*, e2*
106
a* ← a1*
e* ← e1*
a* ← a2*
e* ← e2*
108
CALCULATE a, e
109
CALCULATE KLoff
110
CALCULATE KLon
111
ΔKL ← KLoff - KLon
112
CALCULATE m_{egr}
113
END

Fig.44

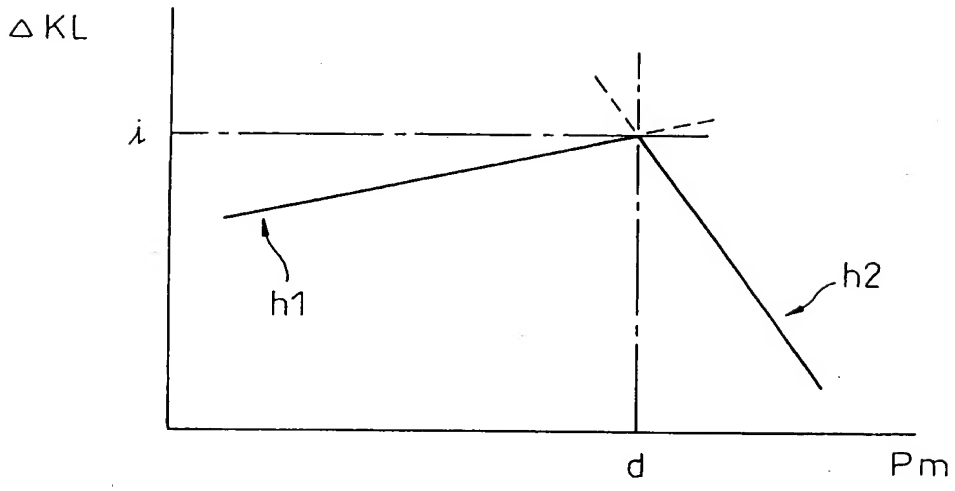


Fig. 45A

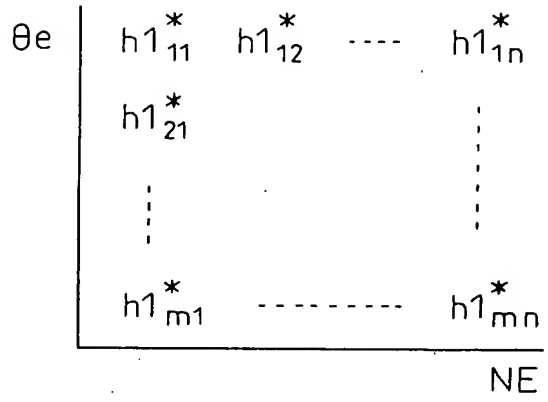


Fig. 45B

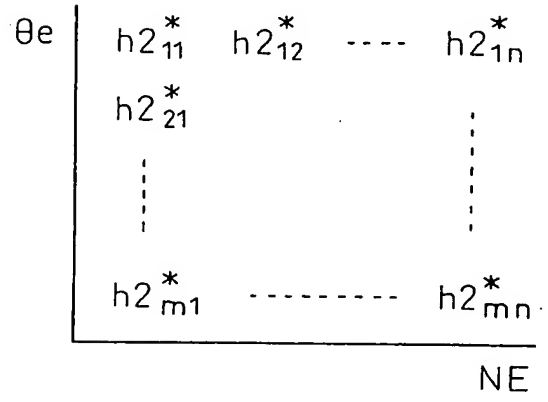


Fig. 45C

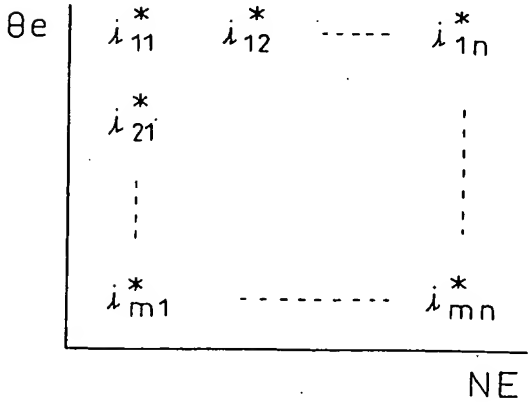


Fig.46

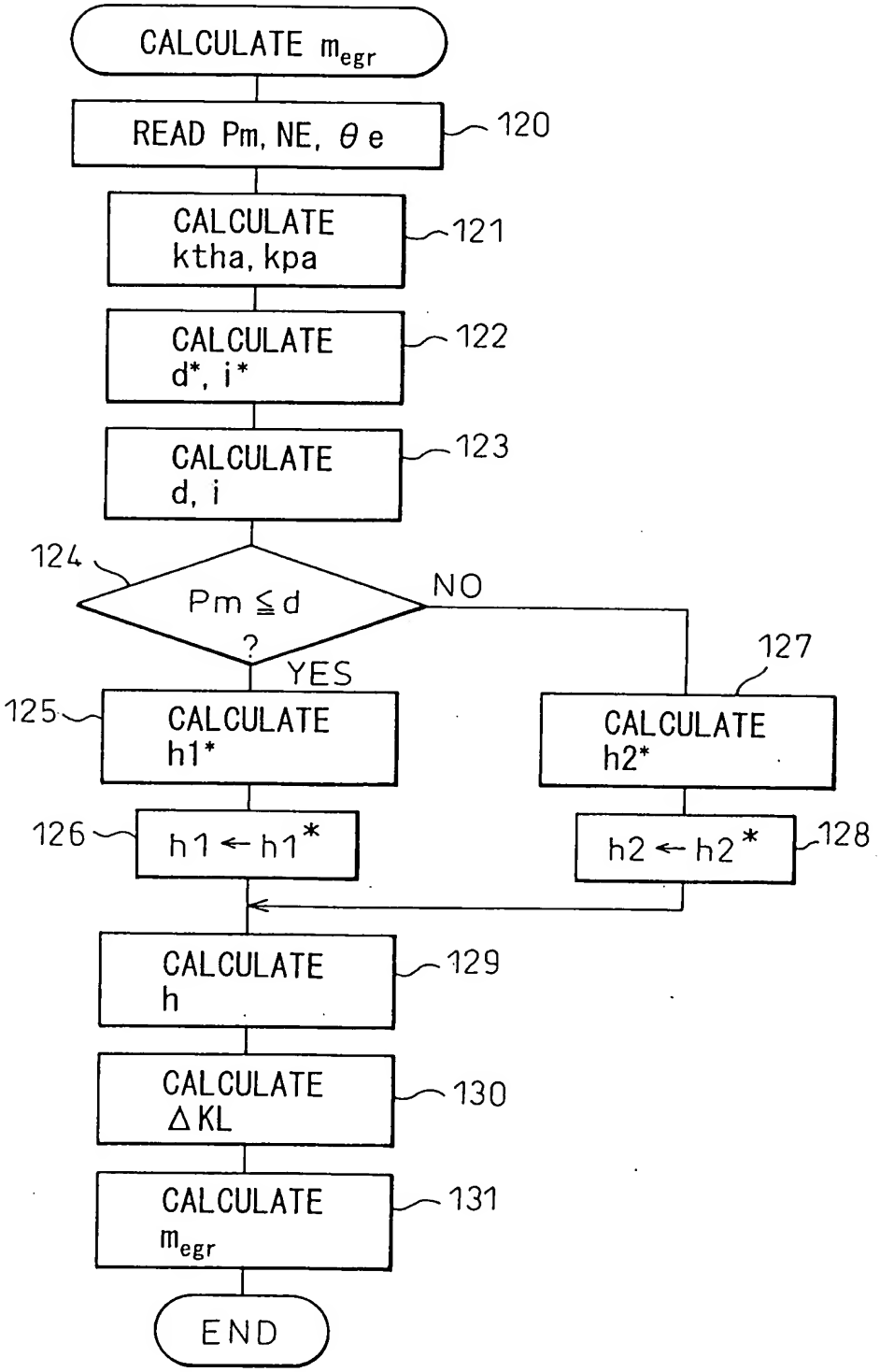

CALCULATE m_{egr}
READ Pm, NE, θe
120
CALCULATE ktha, kpa
121
CALCULATE d*, i*
122
CALCULATE d, i
123
124
Pm ≦ d ?
NO
YES
127
125
CALCULATE h1*
CALCULATE h2*
126
h1 ← h1*
h2 ← h2*
128
CALCULATE h
129
CALCULATE ΔKL
130
CALCULATE m_{egr}
131
END

Fig.47

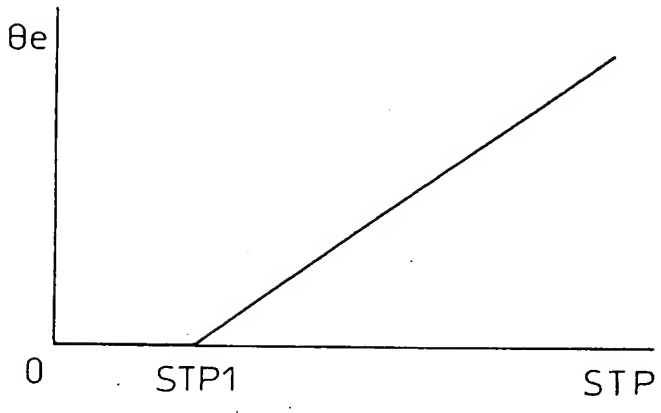


Fig. 48A

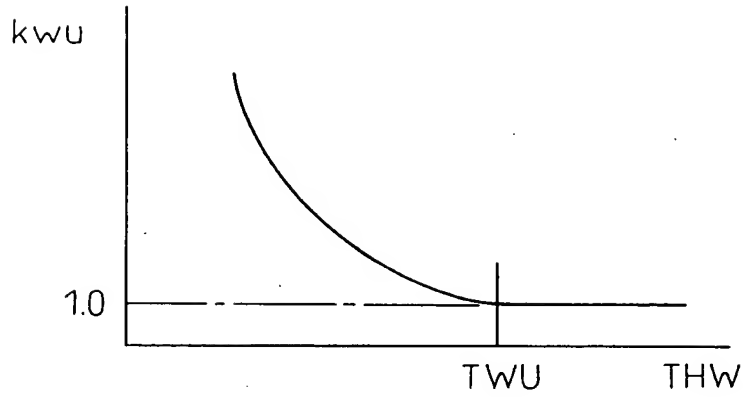


Fig. 48B

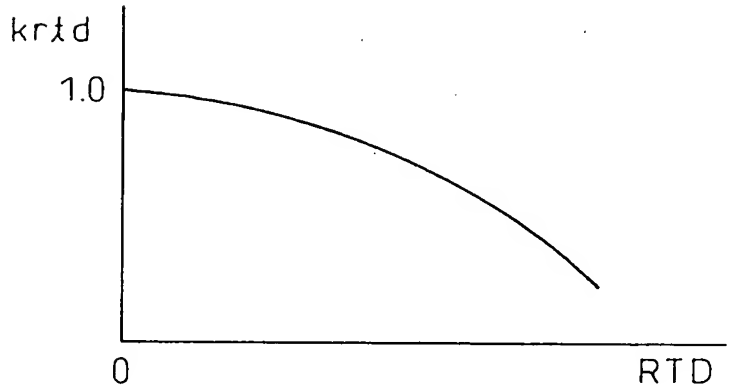


Fig. 48C

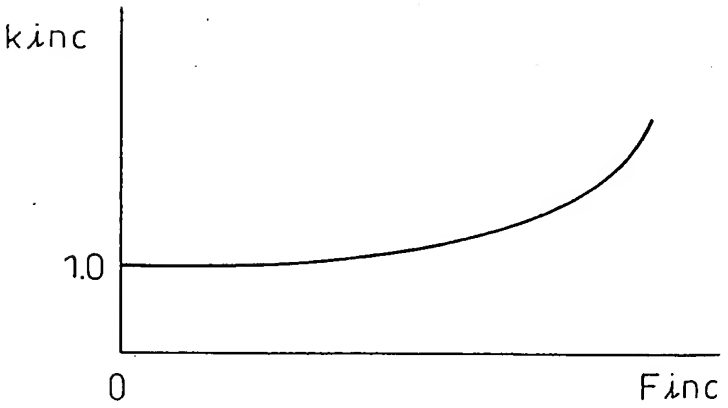


Fig. 49

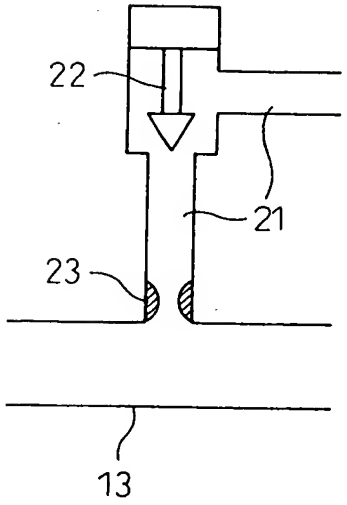


Fig.50A

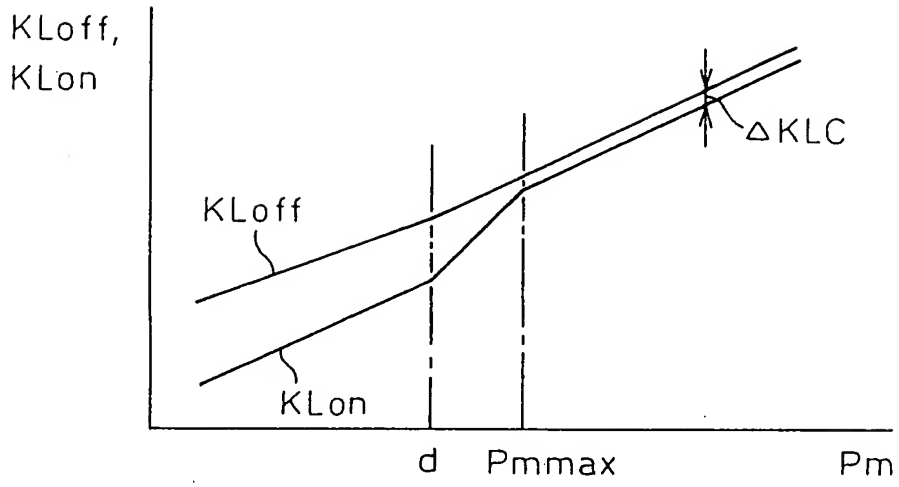


Fig.50B

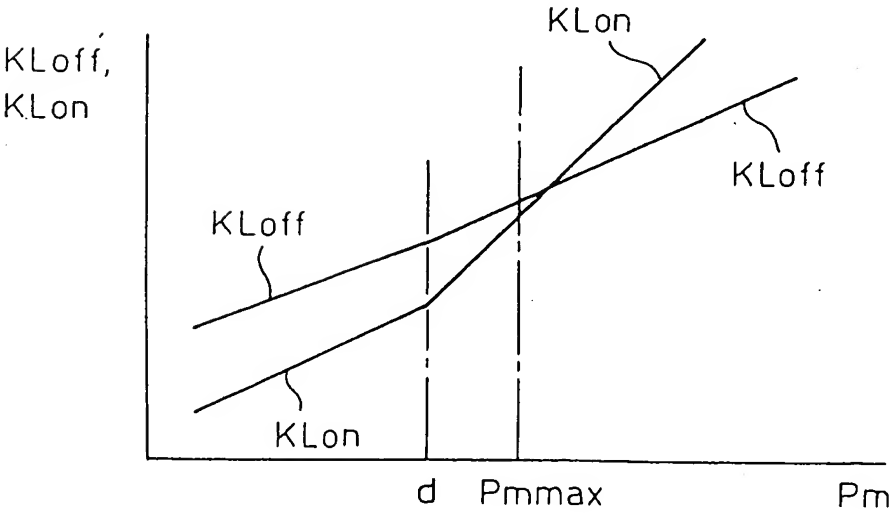


Fig. 51A

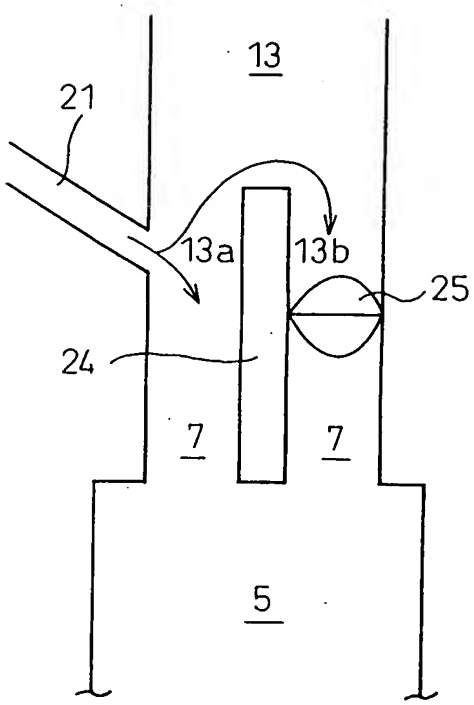
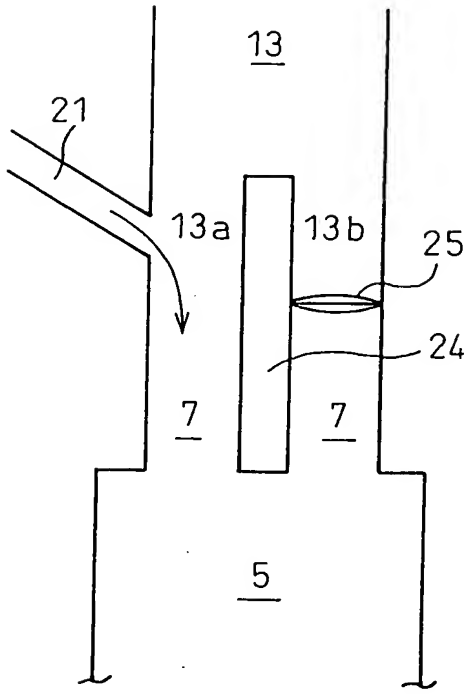



Fig. 51B